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Comparative Seismic Response of RCC and Steel Frame by Pushover Analysis

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***Abstract*: All structures should be made seismic resistant to prevent loss of life and infrastructural damage. Analysis gives an idea about the structural behaviour of RC frame building. For structural engineer, it is necessary to check the performance of multi-storey building before designing. Present work consist of nonlinear static analysis of steel and RCC frame structure. In which it compares performance of G+12 building for both Steel and RCC frame structure under same earthquake loadings. The structure is analyzed for a seismic load combination given in IS 1893:2002. The nonlinear static (pushover) analysis is carried out using software. For the above models the pushover analysis is carried out in ETAB software and the results are shown in the form of mode Shape, pushover curve, lateral forces, base shear to roof displacement graph, hinge formation pattern, time period, base shear and displacement at first yield point, performance point and at collapse point respectively.**

***Keywords*: Seismic analysis, Pushover analysis, ETAB software, performance point, RCC frame, Steel Frame.**

1. Introduction

Now a day's modern era of innovation, two materials consequently used as construction material are steel and concrete for structures ranging from buildings to bridges. Both materials have different properties and characteristics, materials complement each other in many ways. Linear elastic analysis of the structural member is based on stresses up to yield stress. Material is considered as perfectly elastic before yielding. Equation of equilibrium is written on the undeformed configuration which seems to be limited approach of the analysis procedure. To improve this inadequacy, a concept of nonlinear analysis is introduced [2]

Pushover is a static nonlinear analysis method where a structure is subjected to gravity loading and a monotonic displacement-controlled lateral load pattern which continuously increases through elastic and inelastic behavior until an ultimate condition is reached. By performing pushover analysis it is possible to observe the successive damage states of a building. The method is relatively simple to implement, and provides information on strength, deformation and ductility of the structure and distribution of demands which help in identifying the critical state members during the earthquake and hence proper attention can be given while designing [1].

In order to obtain performance points as well as the location of hinges in different stages, we can use the pushover curve. In this curve, the range AB being the elastic range, B to IO is being the range of instant occupancy, IO to LS being the range of life safety and LS to CP being the range of collapse prevention.

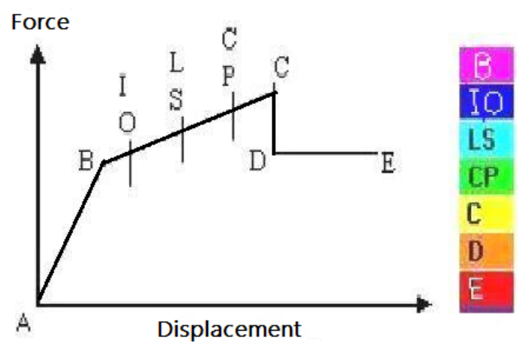

Fig. 1. Different stages of Plastic Hinges

2. Frame Structure Details

In the present study G+12 RCC and Steel frame structure in the zone IV with importance factor 1.0 considered for analysis. Among the various software's ETAB has the capability to incorporate with good manner for both steel section and RCC sections, so for modeling of building software, ETABS 2015 used. The buildings are assumed to be symmetric in plan 20 m*20 m. For earthquakes load consideration IS 1893 (PART 1): 2002 IS used. The details of both the buildings are as shown in the Fig. 2, Fig. 3 and Table1, 2.

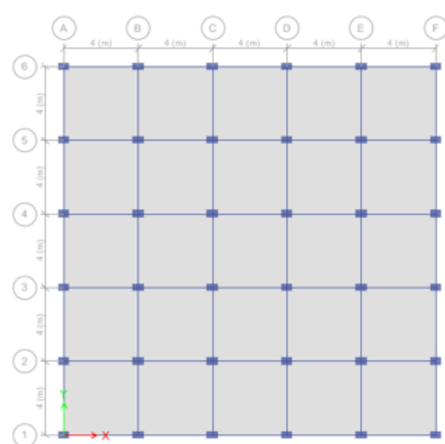

Fig. 2. Plan of G+12 Framed structure

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Table 1
Structural member details

Member	R.C.C Frame Structure	Steel Frame Structure
Column	400 mm x 600mm (12#20ϕ)	ISWB 600-2
Beam	300mm x 500mm	ISLB250
Secondary Beam	-	ISLB200
Slab/Deck	150mm slab	100mm Deck

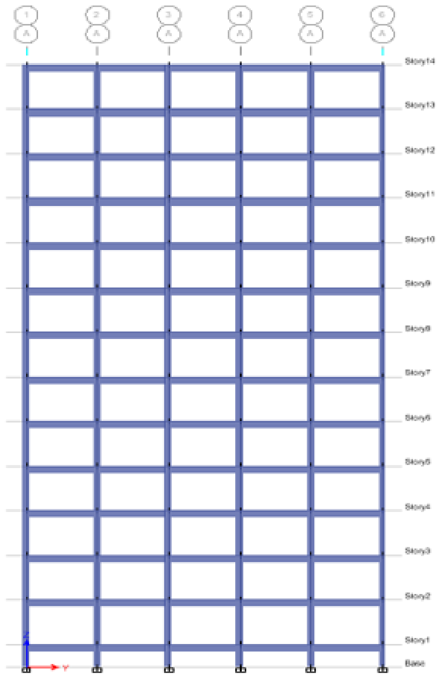

Fig. 3. Elevation of G+12 Framed structure

Table 2
Data for Analysis of RCC and Steel Structure

Storey	G+12 STEEL
Type of frame	Special Moment Resisting Frame
Total height of building	40.5m
Height of each story	3.0m
Plinth height	1.5m
Plan of the building	20m × 20m
Thickness of external walls	230mm
Live load	3.0 kN/sq.m
Grade of Concrete	M25
Grade of R/f Steel	Fe415
Grade of structural steel	Fy = 250 N/mm2
Density of Concrete	25 kN/m3
Density of brick masonry	20 kN/m3
Zone	IV
Soil type	Rock
Importance factor (I)	1.0
Response reduction (R)	5.0
Seismic zone factor (Z)	0.24

3. Methodology

The present study deals with comparative seismic response of G+12 frame structure by Non-linear static Pushover analysis method. The analysis of both the building model is analyzed with the help of ETABS2015 software. Pushover analysis been studied for parameters such as formation of hinges, time period and base shear.

4. Result and Discussion

A. Formation of hinges in G+12 RCC and Steel building

The formation of first and last hinges for G+12 RCC and Steel structure were tabulated and the results drawn on the basis of performance level was shown in Table 3. The column 1 to 16 includes hinge location, model, structure, number of steps, displacement, base shear and various performance levels respectively. The pictorial representation of formation of hinges for G+12 RCC and Steel structure was shown in Fig 4. In elevation, numbers in the rounded circle shows elevation of the frame where a number of hinges form. The green color hinges indicate I.O level, blue indicate L.S level and red indicate C.P level.

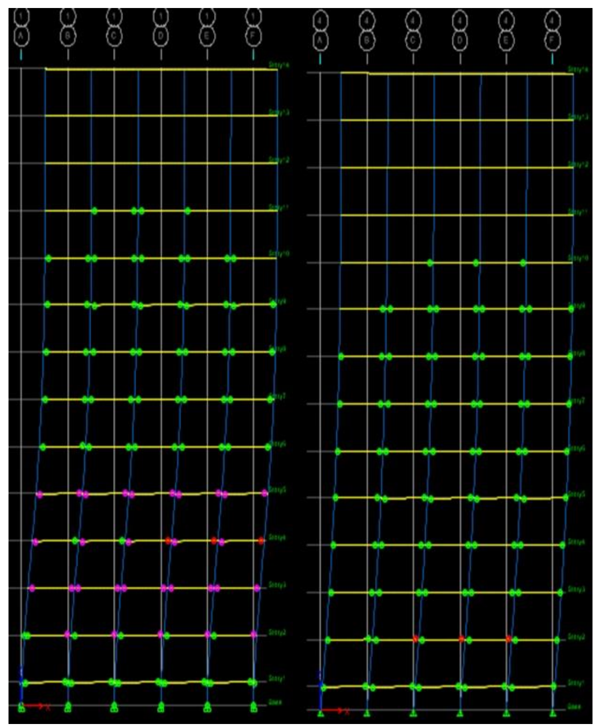

Fig. 4. Formation of hinges in G+12 RCC and Steel building

Table 3 shows the formation of first and last hinge takes places at a displacement of 134.46 mm and 920.17 mm respectively in Steel frame where in RCC it is 31.80 mm and 413.91 mm respectively. Also base shear in steel frame at first and last hinge is 1448.6kN & 3715.9kN respectively whereas in RCC frame it is 2554.2kN & 3734.5kN respectively.

B. Base shear

The base shear value for G+12 RCC and Steel structure was shown in Fig. 5. The base shear values for G+12 RCC frame structure is more than Steel frame structure as it has more seismic weight.

Table 3
Data for Analysis of RCC and Steel Structure

Hinge Location	Model	Structure	No. of Step	Displacement in mm	Base shear in kN	Number of hinges									Total no. of hinges
						Performance Level as described in section 3.2									
						A-B	B-C	C-D	D-E	>E	A-IO	IO-LS	LS-CP	>CP	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
First Hinge Formation	G+12	RCC	20	31.80	2554.2	2178	6	0	0	0	2184	0	0	0	2184
		Steel	83	134.46	1448.6	2182	2	0	0	0	2184	0	0	0	2184
Last Hinge Formation	G+12	RCC	271	413.91	3734.5	1494	502	2	170	16	1664	319	173	28	2184
		Steel	572	920.17	3715.9	1662	510	0	8	4	1730	442	12	0	2184

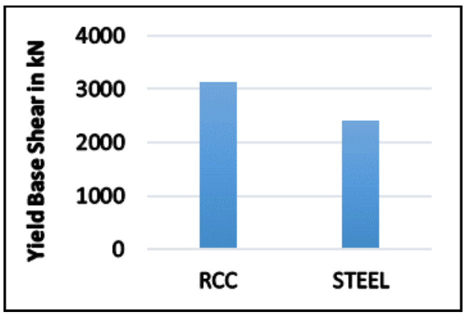

Fig. 5. Base Shear in G+12 RCC and Steel building

C. *Time Period*

After analysis of both the frames it is observed that time period of steel frame structure is more than RCC frame structure due to higher flexibility of steel.

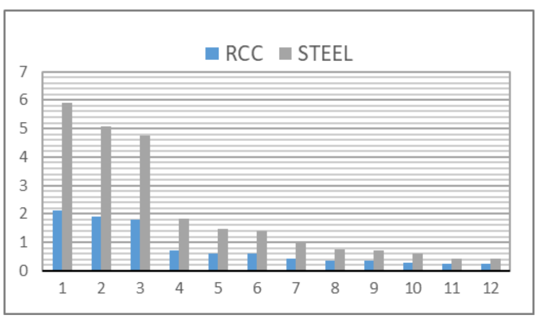

Fig. 6. Mode Shape vs. Time Period for G+12 RCC and Steel building

5. Conclusion

From this study some major conclusion are as follows:

1. Time period for steel frame structure is more as compared to RCC structure because of greater flexibility of steel.
2. The time period for steel and RCC frame structure of G+12 is 5.92sec. & 2.13sec. respectively.
3. In case of steel first hinge formation occurs at displacement value of 134.46mm and in case of RCC is 31.80mm.
4. The base shear found in RCC is more as compared to steel frame structure at first hinge formation. The percentage variation in base shear of RCC and steel frame structure is 56.71%.

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